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LAKE STATES ASPEN REPORT NO. 22

ENEMIES OF ASPEN

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FOREWORD

During and since World War II, there has been increasing interest in aspen (*Populus tremuloides*) in the Lake States, its availability and supply, properties and uses, and management. Aspen is a tree of primary importance in 20 million acres or 40 percent of the total forest area of the three Lake States - Michigan, Minnesota, and Wisconsin.

At an informal meeting at Madison, Wisconsin, in January, 1947, forestry representatives of several federal, state, and industrial groups in the Lake States agreed that it would be desirable to bring up to date what is known on aspen and make it available to anyone interested. The job of preparing this information in the form of reports was assigned to each of the groups listed below. The reports will be duplicated as rapidly as completed, and the entire project should be finished by the end of 1947. Each report will concern one aspect of the subject. Copies will be available from the Lake States Forest Experiment Station or from each contributor.

Report Number	Subject
1	Aspen Properties and Uses
2	Aspen Availability and Supply
3	Logging Methods and Peeling of Aspen
4	Milling of Aspen into Lumber
5	Seasoning of Aspen
6	Aspen Lumber Grades and Characteristics
7	Mechanical Properties of Aspen
8	Machining and Related Properties of Aspen
9	Aspen Lumber for Building Purposes
10	Aspen for Containers
11	Aspen for Core Stock
12	Small Dimension and Other Industrial Uses of Aspen
13	Aspen for Veneer
14	Aspen for Pulp and Paper
15	Aspen for Cabin Logs
16	Aspen for Excelsior
17	Aspen Defiberization and Refining of Product
18	Chemical Utilization of Aspen
19	Preservative Treatment of Aspen
20	Marketing of Aspen
21	Possibilities of Managing Aspen

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E N E M I E S O F A S P E N

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REPORT NO. 22

ENEMIES OF ASPEN

By
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University of Minnesota

and Paul O. Rudolf
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So long as aspen was considered primarily a weed species, there was little concern over the enemies which might injure or destroy it. Sometimes these enemies were actually considered blessings in disguise. Now, however, that aspen not only is the most abundant but also one of the most widely utilized tree species in the Lake States, there is increasing interest in anything that may affect its future supply. For that reason this brief summary of information on the enemies of aspen has been assembled.

The diseases of aspen, notably cankers and woodrots, have caused great concern. However, there are also many other factors which kill or damage aspen trees in the Lake States. Among them are more than a score of insects, several species of mammals and birds, storms and other weather factors, and fires. Often there is an interaction of injurious agencies. For example, trees may be injured initially by storms, animals, or fires, and subsequently insects or disease causing organisms may enter such trees and further weaken or kill them.

DISEASES OF ASPEN[2/]

The diseases of aspen and their effects on the growth and productivity of the trees, management of stands, and utilization have been studied but little in the Lake States. It is apparent, however, that leaf diseases probably are of little importance, that Hypoxylon canker is an important killer of trees in many areas, and that decay caused by Fomes igniarius results in serious reduction of wood volume in older trees. A number of studies of the Hypoxylon canker problem are in progress and some results should be available in the near future.[3/]

1/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Minnesota, University Farm, St. Paul 1, Minnesota

2/ This section was prepared by Clyde M. Christensen, Professor of Plant Pathology, University of Minnesota, and Ralph L. Anderson, Research Assistant, University of Minnesota, and Agent, Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S.D.A.

3/ Studies are being conducted by the U.S.D.A. Division of Forest Pathology, University of Minnesota, the Lake States Forest Experiment Station, University of Wisconsin, University of Michigan, Michigan State College, and several cooperating pulpwood companies.

U.S.D.A. - S.C.S. Milwaukee, Wis., 1951

Leaf Diseases

Leaf diseases do not seem to be of much importance in the management of aspen, but they should be recognized for what they are. Usually they appear in epidemic form only sporadically, and they seldom cause sufficient defoliation to measurably affect the health, vigor, or rate of growth of the trees. Those commonly encountered are described briefly below.

Napicladium tremulae causes a dieback of young tender shoots and leaves of aspen from Maine to Minnesota. Infected terminal twigs usually wilt in early July, and soon turn black. This disease is of wide geographic distribution in aspen suckers, but is not known to cause loss of any significance throughout the range of aspen. Young suckers coming up in very dense stands immediately after clear cutting do not appear to be damaged by this disease even when the growing season is excessively moist.

Sclerotinia whetzelii causes Ink Spot, so named from the black circular spots up to 1/4 or 1/3 inch in diameter that develop on infected leaves during the summer. The spots are raised slightly above the surface of the leaves. Ink Spot is widely distributed and relatively common on quaking aspen, but rare on bigtooth aspen. In eastern Canada the disease sometimes reduces the growth, or even kills trees less than 8 feet tall, but apparently has no serious effect on older, taller trees. In the Lake States, occasional local infections have been found heavy enough to cause noticeable browning of the foliage of relatively large and mature trees, but such infections have no more than a very slight and temporary effect on the vigor of the trees.

Septoria musiva infects the leaves of balsam poplar and causes irregular brown spots which are so common that they are almost an identifying character of balsam poplar. The browning of the leaves caused by this fungus usually does not become extensive until late in August when the trees are almost going into dormancy. It is unlikely that heavy infections this late in the season have an effect any more serious than inducing defoliation slightly in advance of normal. On a number of hybrids and introduced species of poplar, the same fungus causes cankers which often kill the trees, but on the species native to the Lake States it appears to be of little importance.

Several species of Melamosora cause rusts on the leaves of poplars. In the Lake States, heavy infections have been found on cottonwoods, but the defoliations caused were usually so late in the season as to have little noticeable effect on the health or vigor of the trees. Heavy infections of rust on the leaves of forest grown aspen have not been reported.

Cankers

Canker caused by Hypoxylon pruinatum is unquestionably the most serious fungus disease of aspen in the Lake States. Trembling aspen is highly susceptible to Hypoxylon canker, bigtooth aspen is injured occasionally, and balsam poplar rarely is attacked.

The fungus invades the bark of the branches or trunk only through wounds. Experimental evidence indicates that "clean" cuts such as those made with an axe or a knife do not become readily infected, but if the bark is bruised severely, as by striking it with a hammer, 50 to 60 percent of the bruises may be infected. Artificial inoculations of trees indicate that wounds can be invaded by the fungus only when they are very new, before the bark tissues form cork layers to wall off the wound. It is possible that wounds made by some insects permit the fungus to invade the tree.

Within a few weeks after the fungus invades the bark, yellowish, sunken areas appear. These extend relatively rapidly up and down the trunk, but progress more slowly around the trunk. The fungus digests much of the inner tissue of the bark, forming a crumbly black residue laminated with lighter colored layers. If the outer bark is removed from the advancing edge of a canker, a sharp division is seen between the green inner bark of the healthy, noninvaded portion and the black inner bark of the diseased parts. Usually no callus tissue is formed at the border of the canker, probably because the fungus progresses too rapidly to permit this.

The fungus kills the tree by girdling the stem. Small trees may be killed in two or three years, those up to 4 inches in diameter in 5 to 7 years, and larger trees in 10 to 15 years. Sometimes the infected trees die before they are completely girdled. The fungus also decays the wood of the stem relatively rapidly, and the trees usually break off at about the middle of the canker, either shortly before or shortly after death.

Data gathered from sample plots by several different investigators, in different parts of the principal commercial range of aspen in the eastern United States and Canada, indicate that about 20 percent of the trees were either infected at the time of investigation or had been killed by Hypoxylon canker previously. Maximum infection in these studies was about 60 percent of the trees. Infections on branches usually kill only the branches and do not enter the trunk; those on the trunk within the crown may kill only that portion above the canker; but those below the crown are almost invariably fatal to the tree. Heavy infections frequently reduce stand density far below that desired. Trees that could otherwise be harvested in thinnings often are eliminated by the canker. In the Lake States, many young stands are so heavily infected as to be without present or future value. The opening up of aspen stands by Hypoxylon canker may aid succession to more valuable species on some sites, but this is a relatively minor benefit compared with the over-all damage caused to aspen by the disease.

Most investigators of Hypoxylon canker agree that young trees, or the younger portions of old trees, are more susceptible to infection than are the trunks of mature trees. This is borne out by experimental inoculations made by one of the writers -- a high percentage of the trees 3 to 4 inches in diameter became infected, but almost none of the 8- to 10-inch trees did.

Some evidence indicates that the incidence of infection is higher on the poorer than on the better sites. Factors other than site index may have been involved, and further data on this question will be required before a really conclusive answer can be given as to the relation between site index and damage caused by Hypoxylon.

More conclusive data are needed as to the relation of diameter of trees to infection by Hypoxylon, although the trunk does appear to become progressively less susceptible to invasion as it increases in diameter and the bark becomes thicker. The relation of tree vigor to infection also is not yet clear, although observations made by one of the writers in 1949 tend to support earlier Canadian studies which indicated that the more vigorous trees are just as susceptible to infection as the less vigorous ones. Current research indicates that infection in well stocked stands is less than in poorly stocked stands. Understocking, therefore, may favor increased incidence of the disease.

No specific control measures have yet been formulated, but common sense suggests that, in thinning operations, all trees infected by Hypoxylon be cut. If left standing they not only will be killed by the fungus in a few years but will also furnish a source of inoculum to infect the remaining trees.

Nectria parasitica causes occasional cankers on aspen. Usually these are oval, with prominent successive ridges of callus tissue or wood from which the bark drops off. Sometimes, especially on slow growing trees on poor sites, Nectria cankers may extend for several feet along the trunk, and the bark will remain on, so that the cankers are evident only by a sunken area on the trunk. Usually the fungus advances very slowly through the bark, and an infection of 15 or 20 years' standing may be only 8 or 10 inches wide and involve only 1/4 to 1/3 the circumference of the trunk. Nectria seldom kills trees, and it does not decay the wood. It even seems to protect the wood from invasion by wood rotting fungi that normally would enter such exposed portions of the trunk.

Since Nectria cankers seldom are common on aspen and when they do occur rarely kill the tree or expose the wood to invasion by decay fungi, they do not seem at present to be of much practical importance.

Cytospora chrysosperma, according to good evidence, is a normal inhabitant of the bark of aspen, and invades the living portion of the bark only when the tree is dying of other causes. One of the writers inoculated numerous aspen trees with cultures of Cytospora from several different sources, and not a single canker resulted. However, when the trees died

several years later as a result of constriction from metal bands fastened around their trunks, Cytospora fruited throughout most of the bark of the trunk shortly after the inner bark below the constricting bands was completely dead. Cytospora canker may be of some significance on introduced varieties or on some hybrids, but there is no evidence to indicate that it is more than a saprophyte in the bark of forest aspen.

Roughbark

Macrophoma tumafaciens infects the outer bark and causes roughbark of aspen, a condition in which the normally smooth, white bark of the trunk becomes roughened and dark, usually in bands that extend part or all of the way around the stem. Other fungi and also lichens may possibly cause similar symptoms. Roughbark as such has no measurable effect on the health or vigor of the trees, but some observational evidence indicates that roughbark is likely to be more prevalent and prominent on trees growing on poor sites. Thus the presence of roughbark may be an added, but not infallible, criterion of site quality.

Decay

Fomes igniarius is the principal cause of heartrot in aspen throughout the entire range of the tree. It invades the tree chiefly through branch stubs, progresses upward and downward in the inner wood of the trunk at the rate of a few inches to a foot or more per year, decays and consumes the wood, and eventually forms fruiting bodies or conks at the branch stubs. The conks are hoof-shaped, black on top, brown on the bottom, and are well known to most foresters who deal with aspen. When first formed, the conks are little more than a brown crust on the under side of a branch stub, but they increase slowly in size from year to year. They are difficult to see until they are at least 5 to 10 years old. It has been stated that the presence of a conk of this fungus on the trunk of aspen indicates decay from 4 to 6 feet above and below the place where it occurs. While such a rule-of-thumb might apply to a given locality, it probably could not be considered a reliable general rule. Obviously a tree with a single conk two years old would have less extensive decay than one with a conk 20 or 30 years old. Factors such as site index, amount of suppression, rate of growth of the tree and others would make it difficult to establish any general rule for accurately estimating cull from conks or other outward symptoms.

Since Fomes igniarius enters chiefly through branch stubs, and branch stubs normally become more numerous as aspen trees grow older and the lower branches become shaded out, decay will increase with increasing age of the trees. Studies made in Minnesota some years ago indicated that as aspen increased in age beyond 50 years, the loss of wood volume from decay began to exceed the annual increment of sound wood, and that this loss from decay became progressively greater as the trees grew older. While these general conclusions are of considerable value in telling us how

Fomes igniarius operates, they are subject to considerable modification in the handling of individual stands of aspen. In some areas, there is relatively little decay in aspen even when it has exceeded an age of 50 years; in others, decay causes heavy losses before the trees become 50 years old.

What the wood is to be used for may have an important bearing on the loss caused by Fomes igniarius rot. Where the trees are cut for lumber or dimension stock, decay is obviously important, especially since it reduces the amount of sound material that could otherwise be obtained from the central portion of the trunk. Recent unpublished studies made by one of the firms using aspen in the manufacture of insulation board indicate that even extensive decay results in relatively little loss in volume of final product obtained from the tree. This suggests that for certain uses trees decayed by Fomes igniarius need not be discriminated against. Obviously, rather intensive studies are needed to determine the relation of this rot to aspen management in specific areas, and for specific purposes.

Fomes applanatus rots the roots and butts of occasional aspen trees, but is not known or suspected to be sufficiently prevalent to cause much loss.

When aspen logs are cut and piled, they are soon invaded by a great variety of wood-rotting fungi that gradually decay them. There are several dozen species of wood-rotting fungi known to grow vigorously in moist aspen wood. If the wood is piled where it does not dry out readily, these fungi are able to cause some reduction in volume, and in quality for certain uses, during a single summer, and considerable loss during the course of two summers. All or nearly all of these fungi cause white rots. Presumably a certain amount of this decay does not greatly reduce the volume or quality of the wood for certain purposes, but eventually, of course, the major portion of the wood is consumed. No detailed studies of the practical significance of these rots have been reported, but such studies are needed to give added information on the utilization of aspen.

ASPEN INSECTS IN THE LAKE STATES[4/]

Among the various insects known to attack aspen, the leaf-feeding species usually cause the most conspicuous and important damage. They are represented by insects which produce all five major types of leaf injury; namely, free feeders, skeletonizers, leaf rollers, leaf miners, and gall makers. Of these, the free feeders such as the forest tent caterpillar have been the most destructive. There are also a number of wood-boring insects found in aspen, of which only the poplar borer is of particular economic significance. Of less importance are several species of scale insects and aphids which commonly are present in aspen stands.

4/ This section was prepared by A. C. Hodson, Professor, Entomology and Economic Zoology, University of Minnesota; published as University of Minnesota Agricultural Experiment Station Miscellaneous Journal Series No. 736.

Leaf Feeders

The forest tent caterpillar, Malacosoma disstria, is unquestionably one of the most important insect pests of aspen. Not only does it cause mortality or a great reduction in radial growth in completely defoliated stands, but also it is considered a serious nuisance by residents and visiting tourists in areas where outbreaks occur. In fact, the indirect economic losses and annoyance suffered in resort areas often may be more important than direct damage to the forest. On the other hand, the forest tent caterpillar has been considered a beneficial insect because of the release given desirable conifers when poor-site aspen is killed by repeated defoliation. Although there is actually little or no observational evidence to support this opinion, it does seem to be a reasonable assumption which should be investigated.

On the average the eggs of the forest tent caterpillar hatch during the first two weeks in May in the latitude of northern Minnesota. At first the feeding of the small larvae is scarcely noticeable but by early June, after the fourth molt takes place, defoliation proceeds at a very rapid pace. In fact, the last instar larvae consume about 80 percent of the foliage eaten during the entire feeding period. This explains why many people have thought that there was no need for spraying in May only to have the older larvae appear as if from nowhere later in the season. About the middle of June the larvae spin cocoons in the leaves of the host trees and in woody shrubs and ground vegetation. Pupation takes place in the cocoons and is followed by moth emergence, usually during the first three weeks of July. The eggs are deposited in masses that encircle the twigs of the host trees. They develop until ready to hatch and then become dormant until spring.

Records show that there have been forest tent caterpillar outbreaks in the Lake States at approximately 10-year intervals. They have persisted for a few years and then the insects have subsided to a very low population level, even to the point of complete local disappearance. In most cases, complete defoliation has been observed for no more than three successive years in any one locality. However, a major outbreak may continue for five or more years over a large area, dying out at the initial points while continuing to build up over an increasingly large acreage. The records available also suggest that the outbreak which terminated in Minnesota in 1938 was of longer duration and much more extensive than those recorded in former years. This change is associated with the tremendous increase in the acreage occupied by aspen over the past 50 years, and suggests what we may expect in the future.

The current outbreak, which was noticed first in Minnesota in 1948 at Basswood Lake in the Superior National Forest, is threatening to repeat the widespread defoliation experienced a little over a decade ago. Another outbreak center has been reported for 1949 and 1950 in the eastern end of the Upper Peninsula of Michigan. Ultimately one or more of several natural

control factors will terminate these new threats. Among the more important natural population checks are parasitism, unfavorable weather (particularly late spring frosts), and starvation in areas where the caterpillars exhaust their food supply.

These outbreaks are expected to die out before there is extensive damage to aspen stands on good sites, but in the meantime there will be some tree mortality on poor sites, and property owners and tourists will be plagued with hoards of the pale bluish, spotted caterpillars which will denude roadside and shade trees and swarm over highways, buildings, and the unwary person who ventures under infested trees. For these reasons, control by aerial spraying with DDT is considered necessary and advisable only in areas of high value where resorts, private property, and scenic routes are likely to be invaded.

Occasionally aspen is defoliated seriously by one or more species of leaf beetles. The American poplar beetle, Phytodecta americana, the cottonwood leaf beetle, Chrysomela scripta, and two introduced species, C. tremulae and C. interrupta, are the most important. With the exception of the largest of these, C. tremulae, which has unmarked reddish-brown elytra (anterior wings), the elytra of the other species vary from yellow to red and are decorated with black spots or stripes. Young larvae are usually black or at least a very dark color, while older larvae are a dirty yellow color. The adults cut holes between the leaf veins, and the larvae may cause extensive damage by skeletonizing the leaf surface.

Four species of leaf rollers are found in aspen stands in the Lake States, the most important being the large aspen tortrix, Archips conflictana. The larvae of this insect feed in rolled leaves that are more or less funnel-shaped. Although there are feeding larvae present in the late summer, the heaviest damage is done in the spring when the larvae become active after hibernation. A few local outbreaks of this species have been observed in northern Minnesota near the north shore of Lake Superior. Another leaf roller called the poplar leaf-folding sawfly, Pontania bozemani, and two other species, P. populi and P. robusta, are found commonly but are of no economic importance. The pale green larvae fold the leaf margin and later the injured portion becomes blackened and unsightly. Additional leaf feeders may be found, but they are of little or no economic importance.

Several species of poplars may become infested with the poplar vagabond aphid, Mordwilkoja vagabundus, which causes a peculiar gall formation consisting of swollen and convoluted leaves at the tips of terminal twigs. Although these galls are not abundant in normal stands, they often become numerous after trees have been heavily defoliated, and in windbreak plantings. Another aphid, Pemphigus populi - transversus, causes the common poplar stem gall which is a globular swelling on leaf petioles. Other species of the same genus may cause similar galls on the leaves. None of them are of economic importance.

Wood Borers

The most important wood borer found in aspen is the common poplar borer, Saperda calcarata. This species attacks the trunks of trees, usually 3 inches or more in diameter, and also bores in the base of young trees at the root crown. During the three-year life cycle, the larvae form tunnels through the wood which cause breakage and ruin the wood for many purposes, particularly the production of veneer. A survey made in 1947 in northern Minnesota showed a high incidence of poplar borer damage at the base of young trees one inch or more in diameter. The percentage of trees infested in the many stands examined showed a strong relationship to site conditions, ranging from 70 percent or more on poor sites to less than 1 percent on good sites. No evidence of wood decay was found to be associated with this type of damage, but carpenter ants commonly occupied the tunnels after they had been vacated by the poplar borer. The presence of the borer can be detected in the forest by observing the fallen particles of woody frass which usually are very conspicuous on the leaves of undergrowth or on the ground litter below infested trees. In addition, the tunnel openings on the trunk usually are surrounded with a varnish-like stain on the bark.

Aspen also is attacked by the poplar-twig borer, Saperda moesta, and the poplar-gall saperda, Saperda concolor, both of which cause conspicuous gall-like swellings on small branches. No serious damage is likely under forest conditions, but shelterbelt plantings and ornamental trees sometimes are injured.

A species of Agrilus, now distinguished from the bronzed birch borer, is a common inhabitant of weakened and dying aspen. This species, A. liragus, generally forms compact, zigzag tunnels under the bark which are unlike the loose, winding galleries produced by the closely related bronzed birch borer, A. anxius. The flat-headed larvae of one or more species of the genus Dicerca are also common secondary invaders of dying and dead aspen, and one species of ambrosia beetle, Trypodendron retusus, is found in dead trees, particularly those that have died during the previous winter.

Scale Insects

Several species of scale insects may attack aspen and other poplars, although they have not caused any serious damage in the Lake States. Among the most common are the oystershell scale, Lepidosaphes ulmi; Putnam's scale, Aspidiotus ancylus; the scurfy scale, Chionaspis furfura; and the brown elm scale, Lecanium corni.

MAMMALS AND BIRDS WHICH DAMAGE ASPEN5/

Several species of animals feed upon aspen in the Lake States. Except for beaver and moose, few of them cause mortality to trees beyond seedling size. All these animals, however, cause injuries which retard growth and make the tree more susceptible to attack by fungi and insects.

In many instances the wildlife may be of greater value than the aspen, and the damage may, therefore, be justified economically. In other instances, wood production may be of highest value and control measures against wildlife species may be required. Ordinarily, where animal populations remain in balance with their environment, both wood and wildlife crops can be grown together.

Beavers use aspen as one of their favorite foods, although they feed also upon a number of other woody plants as well as aquatic vegetation. For food and for construction of dams and lodges, beavers will cut aspen trees up to 11 or more inches d.b.h. However, they prefer smaller trees averaging about 2 inches d.b.h. Since small trees are preferred, suckers often are eaten and regeneration thus prevented. Wild beavers in Michigan have cut an average of about 215 trees per year per animal. They may cut all the aspen within 500 feet of the home water course, although their operations usually are not over 300 feet from the stream. An acre of aspen probably will support an average colony of 5 beavers for 1 to 3 years. In addition to the trees cut, beavers also kill some aspen by flooding. Often suckering of aspen in flooded areas is prevented. Locally, therefore, beavers can cause considerable damage to aspen.

The white-tailed deer will eat aspen when other more favored browse is unavailable. Aspen has been ranked as a poor second choice or even starvation winter food. Ordinarily only small twigs and sprouts are eaten. However, where populations become high, deer may damage aspen reproduction quite extensively. A survey showed that 30 to 40 percent of the aspen reproduction in northern and central Wisconsin was heavily browsed by deer. Another study showed that aspen made up 25 percent of the winter browse consumed by deer in central Wisconsin; only willow was browsed more heavily. Because of their abundance and the reluctance of sportsmen to support adequate hunting pressure, deer probably will continue to damage much aspen reproduction in parts of the Lake States.

The snowshoe hare eats aspen sprouts and may girdle small trees. A survey disclosed that 5 to 10 percent of the aspen reproduction in northern Wisconsin had been browsed by hares. During the 2 or 3 years when the hares approach population peaks (about every 10 years), they undoubtedly destroy large numbers of aspen seedlings. At other times they may actually be beneficial through thinning dense clumps of sprouts. Within its range, the cottontail rabbit also browses on aspen.

5/ This and following sections were prepared by Paul O. Rudolf, Forester, Lake States Forest Experiment Station. Unpublished information was made available by L. W. Krefting of the U. S. Fish and Wildlife Service.

Moose browse aspen in preference to other plants as a winter food. Ordinarily they consume only twigs within their reach, but when populations become very high, as on Isle Royale, they bark and often kill standing trees. Reproduction also is consumed under those conditions. Since moose are found only in northern Minnesota and on Isle Royale, they will cause but little damage over the region. Elk, also rare in the Lake States, may strip aspen in a few localities.

Red squirrels, black bears, and porcupines also are reported to feed on aspen to a slight extent. Sheep and goats find aspen very palatable, and cattle also will browse aspen. Where abundant, domestic livestock can damage aspen considerably.

Ruffed grouse feed on aspen all year around. In the summer they feed largely on leaves, but in the fall, winter, and spring the grouse eat aspen buds. While this damage seldom is serious directly, it may retard growth and probably provides avenues of entrance for disease organisms and insects. Both the sharptailed and pinnated grouse feed on aspen buds in a similar manner, but they are much less abundant within the commercial range of aspen. The sapsucker, too, is known to do some damage to aspen.

CLIMATIC FACTORS

Although aspen is well adapted to the climate within its range, it sometimes is damaged seriously by storms. Periodic heavy windstorms have caused breakage in aspen stands over extensive areas in the northern Lake States. Breakage may be particularly heavy in badly cankered stands, but sound trees, too, are broken in the severe storms. Wet, heavy snows and glaze storms also cause heavy breakage at times.

Bad hail storms are known to cause numerous bruises on aspen stems. Hypoxylon pruinatum, which is known to infect aspen readily through bruises, may follow.

Severe droughts, such as were prevalent in the early 1930's, seldom kill aspen beyond the young seedling stage. However, they weaken the trees and predispose them to injury by insect or disease.

FOREST FIRES

Aspen now is the most abundant forest type in the Lake States. Largely as a result of the widespread forest fires which swept the region between 1870 and 1920. However, while fire favors the establishment of aspen and may even stimulate suckering in newly felled areas, it can be detrimental to established stands. Not only can fires kill merchantable aspen or weaken them so other agencies can kill them, but they can also reduce the productivity of stands below merchantable levels. A study in Wisconsin indicated that moderate or severe burns in aspen stands largely eliminated the prospects of their profitable management on all but the better soils (good sandy loams or finer in texture).

WHAT IS NEEDED

A large number of enemies of aspen are known, but there is little detailed knowledge concerning most of them. Because aspen has now assumed great importance as a source of wood, there is need for more knowledge about those enemies. Their extent, the conditions under which they become serious, possibilities and desirability of control, feasible methods of control where justified -- all of these need to be explored further and worked out specifically.

Results of current exploratory study of Hypoxylon pruinatum are about ready for dissemination. Doubtless they will point out promising leads for further study of this disease, now considered the most important enemy of aspen. Likewise, if aspen stands are going to be managed at all intensively, we shall need to know more about the other disease causing organisms, insects, mammals, birds, climatic factors, and fire which damage this tree.

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